

## A Comparison of Sicilian and Three American Species of Sumac for Tanning Sheepskin Skivers\*†

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### Introduction

Sumac tannin, a material derived from the leaves of several species of the *Rhus* genus of plants, is used by tanners for the tanning or retanning of certain types of skins. The leaves are used by extract manufacturers for the production of a liquid extract used by tanners and dyers. Sumac, either as powdered leaf or as extract, does not produce a firm, heavy leather, such as is required for shoe soles or harness, but makes a light-colored, soft, flexible leather, with a good "feel" that is very desirable for certain types of articles in which either light color, light weight, or both are desired. It is sometimes used for retanning to lighten the surface color of heavy-weight leathers. The tanners' requirements are met satisfactorily by Sicilian sumac, an imported product obtained from plants of *Rhus coriaria* L. grown under cultivation in Sicily and harvested, processed and graded in such a way as to insure a uniform, high-quality commodity.

A commercial product known as American sumac has been obtained from Virginia and neighboring states for many years, but it has offered little competition to Sicilian sumac because of its uncertain and generally poor quality. Probably all American sumac has been made into extract; however, exact information on this point is not available. Apparently the marketed product has not been satisfactory for use in the form of ground leaf.

Recently, interest in domestic sumac has increased because it is an excellent plant for controlling soil erosion, which has become a national problem. The amount of land subject to erosion is great, and if sumac is to play an important part in the solution of this problem, an outlet must be found for much more sumac than has been used in the United States heretofore. One means of increasing its use might be the substitution, in certain tannages, of domestic sumac for the materials now being used. Tanners cannot be expected to adopt this practice, however, unless it can be demonstrated that domestic

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sumac produces acceptable leather at a cost that is not prohibitive. Such use would, of course, relieve the shortage of tanning materials to a certain extent.

Before sumac can be advocated as an erosion-control tannin crop, information is needed on another point. Three species of sumac, dwarf (*Rhus copallina* L.), white (*R. glabra* L.) and staghorn (*R. typhina* Torn.) are common in the eastern states. Any one of the three species can be grown under cultivation, and each has certain advantages, as has been pointed out by Sievers and Clarke.<sup>3</sup> All these species are highly effective in controlling erosion on slopes, but the question arises as to their relative value to the tanner. At present dwarf is the preferred species, and the only one desired by some buyers, probably because of its higher tannin content. Some white, however, and perhaps also a small amount of staghorn sumac, have been marketed from time to time either alone or mixed with dwarf, but they probably were not kept separate when made into extracts. At any rate, no comparative data on the relative desirability of the three species from the tanners' viewpoint have been reported, although such information might make it possible to select one of the three species as best suited for development. In an effort to throw some light on this point the tests to be described below were conducted.

In one type of commercial sumac tannage, ground Sicilian sumac is used in a paddle vat to tan sheepskin skivers for shoe linings. For this tannage the sumac should have a tannin content of at least 26 per cent on an air-dry basis or about 28.5 per cent on a moisture-free basis, otherwise so much material must be used to secure the required amount of tannin that movement in the vat is restricted and tanning is unsatisfactory. Up to the present, American sumac has not proved satisfactory for this work, probably because of its low tannin content. A number of laboratory tests, however, have indicated that the fault was in the manner in which the material was gathered and dried rather than in an inherent defect in the native species.

After an examination of the sumacs of the southeastern states, Russell<sup>1,2</sup> concluded from laboratory tanning tests and other considerations that only dwarf sumac appeared promising for the direct tanning of sheepskins. Then in a commercial test made in cooperation with a sheepskin tanner he found that dwarf sumac leaves, if carefully dried, produced leather almost equal to that made with Sicilian sumac. In a later test, in which dwarf sumac leaves were mixed with a moderately large proportion of stems, the tannage was not satisfactory.

The tests described below are similar to those made by Russell, but Sicilian sumac and all three of the American species mentioned above were included on a strictly comparable basis. Only a negligible amount of stems was present

with the leaves of the various lots of domestic sumac. Both white and stag-horn sumacs have large, stemmy petioles and rachises, so portions of each species were processed to remove substantially all this stemlike part of the leaves. This made possible a direct comparison of leathers tanned with leaves and with leaflets.

#### 1942-1943 Tests

The first tests were designed to compare leaves of *R. copallina* and *R. glabra* with ground Sicilian sumac (*R. coriaria*) for tanning sheepskin skivers on a commercial scale. The *R. copallina* leaves were received at the tannery in the summer of 1942, and as it was apparent that there would be considerable delay before the *R. glabra* material could be made ready for use, the tanning tests with *R. copallina* and *R. coriaria* were started and were completed in September 1942. The *R. glabra* leaves were received and prepared for use in February 1943, and the tanning was done in April. The two runs with (a) *R. copallina* and *R. coriaria* and (b) *R. glabra*, respectively, were not strictly comparable in regard to skins but were as nearly comparable in all other respects as was possible in view of the difference in times at which they were made.

The *R. copallina* material was a mixture of six lots of leaves picked by hand at Beltsville, Md., from two-year-old sprouts and dried in several ways as part of a study of drying methods to be reported elsewhere. About three-fourths of it was collected from August 7 to 14, and the remainder on September 26, 1941. Part of the material was dried at prevailing temperatures and part with moderate artificial heat, but none was dried rapidly. At least 3 to 4 days were required for drying each lot. When dry, the material was beaten or flailed to separate leaves and stems, and the latter were discarded. In assembling the material none that was improperly dried or spoiled was included.

The assembled lot of flailed material contained some pieces of stems, especially stem tips, and in order to remove these the material was run through a fanning mill of the type used by farmers for cleaning seed. The weight of the lot was reduced by fanning from 460 pounds to 420 pounds, or 9 per cent. Fanning not only removed the stems but also much of the petiole and rachis material. The proportion of the latter discarded would have been difficult to determine accurately, but it was estimated, based on inspection only, that about three-fourths was removed. This lot therefore consisted essentially of leaflets rather than of leaves. After fanning, the lot was ground in a hammermill to a fineness equal to that of the usual ground Sicilian leaf, and shipped to the cooperating tanner.

Sicilian sumac was supplied by the tanner from a shipment of ground leaf imported some years previously.

The *R. glabra* material consisted of leaves picked by hand in the southeastern part of Iowa during the summer of 1942. After a preliminary drying in the sun and a final drying indoors, the leaves were shipped to the Eastern Regional Research Laboratory. At the laboratory they were cut in a Ball and Jewell cutter having a 2.5-inch screen, mixed by shoveling, and divided into two equal parts. One portion was ground at once in a hammermill to pass a 1/64-inch screen. The other half was separated by air-elutriation\* into leaflet and petiole-rachis portions, the latter being discarded. The leaflets then were ground in the hammermill.

For the first run, 60 dozen sheepskin grain splits were selected on the basis of uniformity of weight and quality from a shipment of extra heavy New Zealand pickled skins that had been depickled, split and repickled by the tanner. They were separated into two packs of approximately equal quality, consisting of 30 dozen each. Since it is not advisable to hold pickled skins too long, none was set aside at this time and held for the tanning tests with white sumac. When the latter was ready for the tanning tests, two additional packs of skins were selected, skins being chosen so that these packs would be as nearly equal to the first two packs as possible. It was necessary, however, to use medium weight skins, whereas the first run was with heavy skins.

Data regarding the amounts of sumac, tannin and skins used in the tests are given in Table I.

The tanning was done in paddle vats of about 1000 gallons capacity that had been cleaned just before the test. About eight o'clock in the morning on the first day of the test, the skins were put into the vat containing 40 pounds of ground sumac, 240 pounds of salt, and about 750 gallons of water. As soon as all the skins were in the paddle vat, enough ground sumac was added to make the amount, including the 40 pounds added earlier, one-fourth the total to be used. At noon another one-fourth of the sumac was added, and the remainder was added the following morning. The paddle was run continuously during working hours for three days. Normally the skins would have been removed after this period, but because of a holiday during the first run they were left in the vat without motion for an additional 3 days. On the sixth day the paddle was run for 30 minutes; then the skins were removed, rinsed, and dried. All four packs were tanned in exactly the same manner. The degreasing, fatliquoring and finishing processes were the same as for the 1944 tests and will be described later in the discussion of those tests.

No difficulty was experienced with any of the four packs at any stage of the tanning and finishing processes. In the tanners' opinion all the leather

\* This process is described under the 1944 tests.

TABLE I  
AMOUNTS OF SUMAC, TANNIN AND SKIVERS USED IN THE 1942-43 TANNING TESTS

Pick No.	Kind	Sumac				Pounds of Tannin per 100 Pounds of Skin
		Weight Lbs.	Non Tannin* %	Tannin* %	Tannin Lbs.	Pickled Sheepskin Skivers Dozen Pounds
1	<i>R. coriaria</i> †	350	19.2	32.2	101.5	698
2	<i>R. copallina</i> leaves	420	20.7	27.3	104.2	690
3	<i>R. glabra</i> leaves	411	20.3	25.0	95.0	650
4	<i>R. glabra</i> leaflets	306	20.3	29.4	82.3	567

\*On moisture-free basis.

†Ground Sicilian Leaf.

TABLE II  
KIND, SOURCE AND COLOR OF THE ELEVEN LOTS OF SUMAC USED IN THE 1944 TANNING TESTS

Lot	Kind of Sumac	Species of <i>Rhus</i>	Source	Predominating Material*	Color of Leaflets	Reflectance of Red %	Reflectance of Green %	Reflectance of Ground Sumac Blue %
A	dwarf	<i>copallina</i>	Wells Tannery, Pa.	leaves	dull green	21.7	21.3	8.7
B	dwarf	<i>copallina</i>	Beltsville, Md.	leaves and leaflets	green	28.1	26.7	10.6
C	dwarf	<i>copallina</i>	Laurel, Md.	leaves	tan	36.0	26.4	13.3
D	white	<i>glabra</i>	Wells Tannery, Pa.	leaflets	dark red	20.0	11.2	7.0
E	white	<i>glabra</i>	Hagerstown, Md.	leaves	green	24.1	22.7	9.2
F	white	<i>glabra</i>	Hagerstown, Md.	leaflets	green	21.0	20.1	7.7
G	staghorn	<i>typhina</i>	Wells Tannery, Pa.	leaves	green	22.2	22.2	9.2
H	staghorn	<i>typhina</i>	Wells Tannery, Pa.	leaflets	green	18.4	19.0	7.0
K	staghorn	<i>typhina</i>	Hagerstown, Md.	leaves	green	23.1	22.7	9.4
L	staghorn	<i>typhina</i>	Hagerstown, Md.	leaflets	green	20.7	20.6	8.4
M	Sicilian	<i>coriaria</i>	Sicily	leaves	tan	30.3	25.8	11.8

\*Leaflets were obtained from leaves by air-elutriation.

†Reflectance relative to magnesium oxide; measured on a photoelectric filter photometer for red (approximately 620 millimicrons), green (546 millimicrons), and blue light (436 millimicrons).

was well tanned and of good quality. Although, for reasons given above, a direct comparison of all four packs was not possible, pack 1 was compared with pack 2, and pack 3 with pack 4. The comparisons were made on the washed, fatliquored skins before any finish coat had been applied to the grain surface.

No difference in feel could be detected between skins tanned with Sicilian sumac and those tanned with *R. copallina*. In the opinion of the tanner, the two packs were equal in softness and fullness. There was a slight difference in color. The skins tanned with *R. copallina*, as a whole, were slightly pinker than those tanned with Sicilian sumac, although the difference was not easily detectable. Many Sicilian sumac tanned skins were pinker than some of the *R. copallina* tanned skins. It seemed doubtful if even an experienced tanner could have separated a high proportion of a mixed lot of the skins into their proper packs.

The two lots of *R. glabra* used for packs 3 and 4, consisting of leaves and leaflets, respectively, produced leathers that were nearly the same in color and feel. Careful inspection of the skins in the crust and again after degreasing indicated that the leaflets produced a slightly lighter color than the leaves, but there was no noticeable difference in feel between the two packs. On the basis of color and feel, the tanner was of the opinion that the leaflets produced slightly better leather than the leaves but that the difference was not great enough to justify a higher price for leaflets.

#### 1944 Tests on Four Species

*Rhus typhina* sumac, which was not included in the 1943 tests, is a large, fast-growing plant that produces large yields of leaves under favorable conditions.<sup>3</sup> It might, therefore, be suitable for cultivation, even though the ratio of stems or wood to leaves is high. A direct comparison of the tanning value of *R. typhina* leaves with those of other species of sumac has not previously been reported. Such a comparison was made under strictly comparable conditions in the 1944 tests. For this work, as in the previous tests, powdered sumac was used for the direct tannage of sheepskin skivers.

During the summer of 1943 sufficient of each of the three American species to tan one or more lots of skins on a commercial scale was collected in several locations. All material consisted of hand-picked leaves with the exception of one lot of *R. copallina*, which was machine harvested. None of the collections contained leaves of any other species of sumac than the indicated one, and the amount of foreign plant material was very small.

*Rhus copallina* was collected in three locations, and *R. glabra* and *R. typhina* were obtained from two locations. The two *R. typhina* and one of the *R. glabra* shipments were each separated at the Laboratory into two equal portions, one of which was air-elutriated to separate petioles. As a

result of this division of certain shipments, a total of ten lots was obtained, or eleven lots, if the Sicilian sumac supplied by the tanner is included.

After receipt of the material at the laboratory, each shipment was cut in a large Ball and Jewell rotary cutter to pass a 2.5-inch screen. The material could then be mixed by shoveling and divided into portions as required. It was also in suitable condition for the air-elutriation process, because during cutting most of the leaflets were broken from the petioles and rachises. Elutriation was accomplished by feeding the cut material into the middle of a vertical pipe 12 inches in diameter and about 25 feet tall. A blower provided an ascending air current in the pipe; it was adjusted to a velocity of about 700 feet per minute. The air-velocity and rate of feed were adjusted by trial until a good separation of leaflets and petioles was obtained, that is, until essentially all leaflets were carried up and all petioles and rachises fell in the air stream. Only the leaflets were collected for use; the petiole portion was discarded. This process removed metallic iron and also any other heavy foreign matter in the leaves. With one exception, all lots not elutriated were passed over a magnetic separator to remove any metallic iron that was present.

The material was ground in a hammermill provided with a standard screen having round holes  $1/64$  of an inch in diameter. The mill was capable of grinding between 200 and 300 pounds of sumac per hour. At regular intervals during grinding of each lot, small portions of the ground sumac were removed from the collecting vessel and, when grinding was complete, were mixed. This sample was reduced in size by riffing to obtain a small sample of the lot for analysis and other testing. The main portion was bagged for transportation to the tannery.

The source of each lot of sumac, the part of the plant that was used, and the colors of the leaflets and ground material are shown in Table II.

Lots B, D, F, H, and L were elutriated and Lots C, E, G, and K were passed over the magnetic separator. Some of the bags of leaves received contained a few lumps or balls of dark or blackened leaves. If pressed tightly during picking, broken sumac leaves or petioles exude a sticky sap that binds the leaves together. Such balls of leaves do not dry readily and usually heat and darken. When the sumac was fed into the cutter during the first operation at the laboratory, all lumps of black leaves found were discarded. Undoubtedly some dark leaves escaped detection, however, and it was impractical to try to remove all partly discolored ones.

A few red leaflets or parts of leaflets were noted in Lots B, C, E, F, G, and H, but it is believed that the amounts were too small to have any effect on the color of the skins tanned with these lots.

Lot A, which was ground first, was given no pretreatment except cutting to 2.5 inch lengths. During grinding it was necessary to stop the mill several

times to remove nails or pieces of wire. Some iron may have passed into the ground product, although analysis of the ash did not show an unusual amount. Cinders, probably from the floor of the drying shed, were also present. They were not removed but were ground with the sumac. The proportion of cinders apparently was not great, however, because the ash content of this lot was about the same as that of the other lots.

Lot B as received contained a small proportion of stems, and in order to remove them this lot was air-elutriated rapidly with the maximum rate of flow of air that could be obtained in the apparatus. This treatment removed some of the petioles also, and to obtain an estimate of the amount, a weighed portion of the discarded material was separated by hand into petiole and non-petiole portions. A calculation based on this separation and on data from other sources regarding the weight of petioles normally present in dwarf sumac leaves indicated that this lot contained only about 58 per cent of the normal amount of petioles.

The material in Lot C was obtained from a field which had been mowed by machine on August 13. It remained in the swath for six days in ideal drying weather, except for a 0.24-inch rain on August 16. It was shocked on August 19 and moved indoors on August 20. During the drying period in the field almost all the chlorophyll had been destroyed by sunlight so that the dry sumac was tan in color.

The amount of material harvested was not enough for a satisfactory test; when ground, there was only 311 pounds, containing 71.2 pounds of tannin.

To have sufficient material for a test, 48.5 pounds of Lot B sumac, containing 14.4 pounds of tannin, was mixed with Lot C. Of the total tannin in the resulting mixture, 83.2 per cent was derived from Lot C and 16.8 per cent from Lot B. This mixture will be designated as Lot C'.

Lot D, obtained in the vicinity of Wells Tannery, Pa., was gathered in the fall after all leaves had turned completely red. The reason for the lateness of collection was that dwarf and staghorn sumacs had been picked in this general location before the white sumac. Because of limited drying space and the risk of accidental mixing of leaves of the three species, only one species was collected at a time. This lot made possible a direct comparison of the tanning action of fully-turned red leaves and green leaves as normally used.

A detailed description of the methods used for drying lots B, C, E, and K will be given in another publication.

Lot M, consisting of ground Sicilian sumac which had been in storage in a warehouse in Philadelphia for five or six years, was used as imported, with no treatment. It contained a small proportion of stems and a few red fragments of leaflets.

The analyses of the eleven lots of sumac are given in Table III.

TABLE III

ANALYSES OF ELEVEN LOTS OF SUMAC USED FOR TANNING SHEEPSKIN SKIVERS IN 1944 TESTS

Lot	Kind of Sumac	Moisture %	Insolubles %	Soluble Solids %	Non Tannins %	Total Tannin* %	Purity of Extractive†	Fixable Tannin‡ %	Astringency§	In Water	pH in 0.01 N H <sub>2</sub> SO <sub>4</sub>
A	<i>R. copallina</i> leaves.....	0.0	1.9	46.9	20.2	26.7	56.9	19.1	71.5	4.1	3.8
		6.2	1.8	43.9	18.9	25.0					
B	<i>R. copallina</i> leaves.....	0.0	1.9	51.4	19.5	31.9	62.1	24.1	75.5	4.0	3.7
		6.8	1.8	47.9	18.2	29.7					
C	<i>R. copallina</i> leaves.....	0.0	1.2	44.5	19.6	24.8	55.7	18.8	75.8	4.1	3.7
		7.7	1.2	41.0	18.1	22.9					
D	<i>R. glabra</i> leaflets.....	0.0	1.9	52.8	20.6	32.2	60.9	25.4	78.9	4.4	3.8
		7.5	1.8	48.8	19.0	29.8					
E	<i>R. glabra</i> leaves.....	0.0	2.0	42.4	19.4	23.0	54.2	16.6	72.2	4.6	4.0
		5.9	1.9	39.9	18.3	21.6					
F	<i>R. glabra</i> leaflets.....	0.0	2.1	48.8	20.3	28.5	58.4	21.1	74.0	4.5	4.0
		6.4	2.0	45.6	19.0	26.6					
G	<i>R. typhina</i> leaves.....	0.0	2.4	39.8	19.6	20.2	50.8	13.6	67.3	4.6	4.0
		6.0	2.2	37.4	18.4	19.0					
H	<i>R. typhina</i> leaflets.....	0.0	3.0	45.6	20.4	25.2	55.3	18.1	71.8	4.5	4.0
		6.4	2.7	42.7	19.1	23.6					
K	<i>R. typhina</i> leaves.....	0.0	1.9	40.6	18.9	21.7	53.4	15.1	69.6	4.6	4.1
		6.1	1.7	38.2	17.8	20.4					
L	<i>R. typhina</i> leaflets.....	0.0	1.3	46.1	19.7	26.4	57.3	18.2	68.9	4.5	4.0
		6.2	1.2	43.3	18.5	24.8					
M	<i>R. coriaria</i> .....	0.0	2.8	50.8	19.9	30.9	60.8	23.3	75.9	4.4	4.0
		8.3	2.6	46.6	18.3	28.3					

\*Total tannin was determined by the method of the American Leather Chemists Association.

†Purity of extractive is 100 times percentage tannin, divided by percentage soluble solids.

‡Fixable tannin was determined by the Wilson-Kern method (5) page 290.

§Astringency is 100 times fixable tannin divided by total tannin.

Tannin in the moisture-free material ranged from 20.2 per cent in Lot G to 32.2 per cent in Lot D, but non tannin ranged only from 18.9 per cent in Lot K to 20.6 per cent in Lot D.

After a three day aging period between tanning and washing, fixable tannin was determined by the Wilson-Kern method.<sup>5</sup> There was a range of from 13.6 per cent in Lot G to 25.4 per cent in Lot D, approximately as great a variation as in total tannin. It was thought that fixable tannin might be more significant than total tannin for this type of tannage, in which the skins are tanned in three days, and then, after being dried and stored for a short indefinite period, are washed preliminary to fatliquoring and finishing. However, the fluctuations in fixable tannin and in astringency, or ratio of fixable to total tannin, did not differ greatly from those in total tannin.

There was 26 per cent or more of total tannin, on the air-dry basis, in only four lots, namely, B, D, F, and M. A direct comparison of leaves and leaflets was possible for 6 lots. The three lots of leaves, E, G and K, were low in tannin, containing only 19.0 to 21.6 per cent but the corresponding air-elutriated lots, F, H and L, which contained 26.6, 23.6 and 24.8 per cent tannin, respectively, should be fairly satisfactory for this type of tannage.

An estimate of the buffering ability of the various lots was obtained by mixing 3 gram portions of the samples with 50 ml. of water and also with 50 ml. of 0.01 *N* sulfuric acid and determining the pH value after five hours. The results, as given in Table III, show that *R. copallina* is slightly more acid than the other species and has a slightly greater buffering action.

The results of sieving tests are shown in Table IV.

TABLE IV  
FINENESS OF GROUND SUMAC AS INDICATED BY SIEVING TESTS

Lot	Kind of Sumac	Proportion that Passed U. S. Standard Sieve Number					
		60 %	80 %	100 %	140 %	200 %	325 %
<i>R. copallina</i>							
A	leaves.....	86.5	68.5	55.4	43.2	32.6	2.7
B	leaves and leaflets.....	90.5	72.7	58.8	46.2	33.3	0.2
C	leaves.....	92.5	75.1	61.9	47.5	34.4	8.3
<i>R. glabra</i>							
D	leaflets.....	85.4	59.2	44.6	30.1	2.7	0.1
E	leaves.....	90.2	66.0	50.8	36.4	23.8	0.7
F	leaflets.....	87.7	61.6	45.8	30.9	4.0	0.1
<i>R. typhina</i>							
G	leaves.....	88.4	65.2	50.9	37.4	26.9	7.4
H	leaflets.....	87.0	58.7	42.4	29.3	9.6	0.2
K	leaves.....	91.0	69.6	52.9	36.6	24.6	5.7
L	leaflets.....	90.4	65.8	47.5	32.0	8.1	0.2
<i>R. coriaria</i>							
M	leaves.....	53.5	38.9	31.6	24.2	17.4	2.9

Since previous work had indicated that grinding in a hammermill to pass a  $\frac{1}{16}$  inch screen gave a product similar to ground Sicilian sumac, all lots were ground in this manner. The data show that the hammermill product was more uniform in size than the Sicilian, as it contained less material retained by No. 60 and No. 80 sieves. The various lots of leaflets contained much less material that passed the No. 200 and No. 325 sieves than the lots of entire leaves; apparently most of the very fine material comes from the petioles.

The pickled skivers used in these tests were third quality, light medium, sheepskin grain splits that had been selected for uniformity of size and weight. They were tied in bundles of one dozen skivers each. The total quantity of tannin available in all lots indicated that 301 dozen skivers could be tanned, on the basis of 5.95 pounds of skin per pound of tannin. This is the equivalent of 16.8 pounds of tannin per 100 pounds of pickled skin or about 0.83 pound of tannin per pound of hide substance. After 301 bundles of skivers were assembled, they were divided at random into eleven piles—one for each lot of sumac. The number of bundles per pile was adjusted, to the nearest one-half bundle (one-half dozen skivers), according to the amount of tannin in the lot to which the pile of skivers was assigned. The quantity and weight of skivers and also the actual weight of total and fixable tannin per 100 pounds of pickled skin are shown in Table V. Just before

TABLE V  
QUANTITIES OF MATERIALS USED IN 1944 TANNING TESTS

MATERIALS USED IN 1944 TANNING TESTS								
Lot	Kind of Sumac	Weight of Ground, Air-dry Sumac, Lbs.	Total Tannin Available Lbs.	Fixable Tannin Available Lbs.	Sheepskin Skivers Pickled		Tannin per 100 Lbs. Skin	
					Doz.	Lbs.	Total Lbs.	Fixable Lbs.
<i>R. copallina</i>								
A	leaves.....	425	106.3	76.1	28.5	631	16.85	12.06
B	leaves and leaflets...	422	125.3	94.8	33.5	744	16.84	12.74
C	leaves.....	*	85.6	64.9	23	510	16.78	12.73
<i>R. glabra</i>								
D	leaflets.....	401	119.5	94.2	32.5	711	16.81	13.25
E	leaves.....	433	93.5	67.6	25	556	16.82	12.16
F	leaflets.....	412	109.6	81.4	29.5	652	16.81	12.48
<i>R. typhina</i>								
G	leaves.....	504	95.8	64.4	25.5	568	16.87	11.34
H	leaflets.....	404	95.3	68.4	25.5	568	16.78	12.04
K	leaves.....	411	83.8	58.3	22.5	500	16.76	11.66
L	leaflets.....	385	95.5	65.7	25.5	568	16.81	11.57
<i>R. coriaria</i>								
M	leaves.....	387	109.5	82.7	30	660	16.59	12.53
Totals.....		4543	1119.7	818.5	301	6668		

\*A mixture of 311 lbs. of Lot C containing 71.2 lbs. of tannin and 48.5 lbs. of Lot B containing 14.4 lbs. of tannin.

each pack of skivers was put into the tanning tub, small clippings were cut from the edges of at least half of the skivers for an analytical sample representative of that pack. Moisture in these samples was determined by drying, in the usual manner, a 10 gram portion consisting of small pieces from a number of the clippings. Then the sample was dried in the air, cut in small pieces, and analyzed. The range and average values for these eleven samples are given in Table VI.

TABLE VI  
RANGE AND AVERAGE ANALYSIS OF 11 SAMPLES TAKEN FROM THE 11 PACKS OF  
PICKLED SHEEPSKIN SKIVERS USED IN THE 1944 TANNING TESTS

*Samples taken from extreme edges of skins*

Determination	Range	Average
Moisture as sampled, %.....	58.2—61.0	59.2
Moisture as analyzed, %.....	7.7—10.4	8.8
Fat, moisture-free basis, %.....	5.0— 6.5	5.8
Ash, moisture-free basis, %.....	39.1—43.6	40.6
NaCl, moisture-free basis, %.....	33.4—47.0	39.6
SO <sub>4</sub> , calculated as H <sub>2</sub> SO <sub>4</sub> , moisture-free basis, %.....	2.3— 2.8	2.6
pH.....	2.8— 2.9	2.9

Tanning was conducted in the same manner as in the 1942-43 tests except for length of time. Four tubs were used, Lots A, B, C, and M being tanned one week, Lots G, H, K, and L the next week, and Lots D, E and F the third week. Tanning was started on Tuesday of the first week at about 8:30 a. m., when the skivers were thrown one at a time into the paddle vats containing 700 to 800 gallons of water, 240 pounds of salt, and a small amount of the ground sumac. The paddle was running while the skivers were being put into the vat and was kept in motion during working hours until the tanned skivers were removed. As soon as the skivers were in the vat about three-tenths of the sumac was added. At 1:00 or 2:00 p.m., another three-tenths was added, and the remaining four-tenths of the sumac was added at about 8:30 a. m. on Wednesday morning.

At 2:00 p. m. on Thursday, while the paddle was still running, about 2 liters of the solution was removed, filtered through a double layer of cheese cloth to remove most of the solid material, and reserved for analysis of the spent liquor. At the same time, liquor was poured through the cheese cloth and squeezed out until sufficient spent ground leaf was obtained to fill a quart jar. This was to provide a sample of the spent leaf for analysis.

The skivers were then pulled from the vat into a tub of water to remove most of the adhering sumac, after which they were placed on horses to drain. At this time about six dozen skivers were taken from each lot, and, after the lot number was stamped on the neck of each with a steel die, they were

combined to form a special pack. These skivers were not selected for quality other than to reject torn or damaged ones. After draining overnight, they were hung in the air to dry.

The analytical samples of spent leaf were folded in linen cloth and pressed in a Carver press at a total pressure of 8000 pounds, or approximately 220 pounds per square inch, and held at this pressure for at least 4 minutes. The moisture content of the various samples of pressed sumac ranged from 27 to 40 per cent. After drying in the air, the samples were analyzed. The results are given in Table VII.

TABLE VII  
ANALYSIS OF SPENT SUMAC LEAF MATERIAL  
RESULTS ON MOISTURE-FREE BASIS

Lot	Kind of Sumac	Insolubles %	Soluble Solids %	Non Tannins %	Tannin %	Purity of Extractive %
<i>R. copallina</i>						
A	leaves.....	2.5	24.9	13.5	11.4	45.8
B	leaves and leaflets	2.2	24.0	12.0	12.0	50.0
C'	leaves.....	2.7	24.2	13.0	11.2	46.3
<i>R. glabra</i>						
D	leaflets.....	4.7	20.7	11.5	9.2	44.4
E	leaves.....	2.3	18.5	10.6	7.9	42.7
F	leaflets.....	2.8	19.9	11.0	8.9	44.7
<i>R. typhina</i>						
G	leaves.....	2.4	19.1	11.8	7.3	38.2
H	leaflets.....	2.8	19.2	11.3	7.9	41.1
K	leaves.....	2.3	19.2	11.5	7.7	40.1
L	leaflets.....	2.4	19.6	11.2	8.4	42.9
<i>R. coriaria</i>						
M	leaves.....	4.2	22.4	13.2	9.2	41.0

Tannin in the spent leaf was high, ranging from 7.3 per cent in Lot G to 12.0 per cent in Lot B. This method of using sumac would not be expected to result in efficient leaching, but another reason for the high percentages of tannin is that 16.8 pounds of tannin was used per 100 pounds of pickled skin rather than the 15 to 15.5 pounds ordinarily used for a three-day tannage. More liberal allowance of tannin was made in these tests because of the unknown nature of certain lots.

An analysis of the spent liquor as taken from the tub would be unsatisfactory because of the large amount of salt in it. Therefore, before analysis, 100 ml. of the spent liquor was pipetted into a cellophane dialyzing sack and dialyzed in water to remove salt. The dialyzed solution was rinsed into a 500 ml. volumetric flask, made to volume, and analyzed by the usual method, except that 15 grams of wet hide powder was used instead of 46 grams per

200 ml. of solution. Undialyzed solutions were analyzed also, but the data are not reported here. The tannin values agreed reasonably well in most cases with those for the dialyzed solutions but were less reliable than the latter because the weight of salt in the dried residues greatly exceeded the weight of organic matter. The results for dialyzed solutions are given in Table VIII.

TABLE VIII  
ANALYSIS OF SPENT SUMAC TANNING LIQUORS  
AFTER DIALYSIS TO REMOVE SALT

Lot	Kind of Sumac	Insolubles %	Soluble Solids %	Non Tannins %	Tannin %	pH of Original Liquor before Dialysis
<i>R. copallina</i>						
A	leaves.....	0.06	0.54	0.42	0.12	3.89*
B	leaves and leaflets	0.05	0.43	0.35	0.08	3.75*
C'	leaves.....	0.04	0.42	0.33	0.09	3.82*
<i>R. glabra</i>						
D	leaflets.....	0.02	0.57	0.36	0.21	3.78
E	leaves.....	0.05	0.49	0.33	0.16	4.03
F	leaflets.....	0.11	0.53	0.31	0.22	3.97
<i>R. typhina</i>						
G	leaves.....	0.08	0.45	0.30	0.15	4.03
H	leaflets.....	0.08	0.41	0.27	0.14	3.93
K	leaves.....	0.06	0.37	0.22	0.15	4.08
L	leaflets.....	0.06	0.38	0.22	0.16	3.97
<i>R. coriaria</i>						
M	leaves.....	0.04	0.39	0.29	0.10	4.17*

\*Liquor stood in laboratory 4 days before being measured; pH is about 0.06 low as indicated by results on remaining lots which were measured as soon as received at the laboratory and again after 4 days.

The percentage of tannin in the liquor is low but represents between 6 and 15 pounds of tannin in solution in the vat.

In the spent leaf, tannin was highest for *Rhus copallina*, next highest for *R. coriaria*, and least for *R. typhina*. There was less tannin in the spent liquors of *R. copallina* and *R. coriaria* than in those of the other two species. Apparently it was more difficult to leach the last fraction of tannin from *R. copallina* and *R. coriaria* than from the other species under the conditions prevailing in this tannage.

When air-dry the skivers were degreased by solvent, then fatliquored with about 2 per cent of their weight of sulfonated cod oil in a large paddle vat filled with warm water. Because of the relatively large volume of water used in the vat, much of the water soluble matter derived from the sumac was washed from the skivers during this process. After removal from the vat, the skivers were horsed up, struck out, and dried in a toggle drier.

Further finishing operations were of no interest in these tests. The tanner,

however, observed each lot of skivers at every step in the finishing process to note any abnormal behavior.

Satisfactory comparisons of the various lots by using all 301 dozen skivers would not have been feasible, so all comparisons were based on the 6 dozen marked skivers of each lot. The 6 dozen marked skivers were combined to form one special pack, which was handled in exactly the same manner as the remaining skivers.

An examination was made at the crust-dry stage and again after solvent degreasing. These examinations were rather superficial, because the skivers could not be handled much for fear of damaging them. All seemed to be well tanned, and no striking differences between the various lots could be noted. Differences in apparent thickness, weight, stiffness, and stretch were not great enough to be detected with certainty; that is, the differences between lots did not seem greater than the variations due to the skivers within the lots. The *R. copallina* and *R. coriaria* tanned skivers were pinkish, but the latter leather was the whiter of the two. *R. glabra* and *R. typhina* produced yellowish leather with none of the pink cast. At the crust stage, Lot C was nearer in color to the Sicilian-tanned skivers than any of the other lots. Lot D was, of course, dark red because it had been tanned with red leaves.

After fatliquoring and drying, the entire lot of marked skivers was taken to the laboratory for careful examination. Each skiver was numbered so that individual records could be kept. It was necessary to reject some skivers because of illegible or doubtful marking, but a total of 733 skivers were identified and measured. Only weight, area, thickness, stiffness, and color were measured, as it was not permissible to cut the skivers. All measurements except color and area were made in a room maintained at 70° F. and 65 per cent relative humidity. Area was measured by machine at the tannery after all work at the laboratory had been completed. Table IX shows the average values and standard errors for the various measurements for each lot. An analysis of variance<sup>4</sup> of these data is presented in Table X.

Color or lightness was evaluated by determining the percentage reflectance relative to magnesium oxide for green light (546 millimicrons) with a photo-electric filter photometer using 45° incidence and normal viewing. This method was considered applicable to these leathers because they were near white, but it might not be applicable to all leathers. Measurements were made near the center of the skins, as the edges were slightly darker than the center because of more exposure to light during storage and handling. Stains and discolorations were avoided if possible.

The data show that there were statistically highly significant differences in lightness due to the tanning agent. Leaflets produced lighter leather than leaves. Species of sumac was also of importance; the order of decreasing

TABLE IX

PHYSICAL MEASUREMENTS ON FATIQUED SKIVERS. AVERAGE VALUES AND STANDARD ERRORS FOR EACH LOT

Kind of Sumac	Lot	Skivers Measured	Color* %	Weight per Skiver Grams	Area per Skiver Sq. Ft.	Thickness†					Av. mm.	Stiffness ‡ mm.	
						1 mm.	2 mm.	3 mm.	4 mm.	5 mm.			
<i>R. Copallina</i>													
leaves.....	A	67	48.04 ± 0.22§	310.75 ± 4.16	10.50 ± 0.07	0.739	0.641	0.619	0.644	0.687	0.666	61.66 ± 0.72	
leaves and leaflets.....	B	67	50.33 ± 0.19	317.51 ± 4.22	10.18 ± 0.08	0.765	0.668	0.658	0.701	0.746	0.708	59.14 ± 0.50	
leaves.....	C'	65	50.12 ± 0.21	316.29 ± 4.18	10.15 ± 0.08	0.742	0.675	0.669	0.690	0.726	0.700	60.62 ± 0.65	
<i>R. glabra</i>													
leaflets.....	D	66	43.95 ± 0.21	300.48 ± 3.16	10.37 ± 0.07	0.695	0.623	0.614	0.655	0.682	0.654	67.11 ± 0.70	
leaves.....	E	66	47.00 ± 0.22	305.64 ± 3.20	10.38 ± 0.07	0.689	0.618	0.602	0.643	0.674	0.645	67.72 ± 0.66	
leaflets.....	F	67	48.25 ± 0.28	307.36 ± 3.53	10.30 ± 0.06	0.708	0.629	0.626	0.644	0.685	0.658	68.13 ± 0.68	
<i>R. typhina</i>													
leaves.....	G	66	46.44 ± 0.23	318.79 ± 3.80	10.42 ± 0.07	0.721	0.636	0.622	0.653	0.699	0.666	67.45 ± 0.74	
leaflets.....	H	69	47.34 ± 0.24	295.55 ± 3.38	10.41 ± 0.06	0.674	0.610	0.585	0.608	0.645	0.624	67.09 ± 0.70	
leaves.....	K	64	46.41 ± 0.22	310.25 ± 3.70	10.41 ± 0.07	0.678	0.620	0.608	0.629	0.670	0.641	69.55 ± 0.66	
leaflets.....	L	69	47.50 ± 0.19	293.96 ± 2.70	10.24 ± 0.06	0.681	0.596	0.586	0.609	0.639	0.622	67.10 ± 0.64	
<i>R. coriaria</i>													
leaves.....	M	67	51.27 ± 0.27	305.03 ± 3.59	10.48 ± 0.07	0.725	0.630	0.605	0.632	0.674	0.653	67.13 ± 0.66	

\*Reflectance relative to magnesium oxide for green light (546 millimicrons); measured on a photoelectric filter photometer using 45° incidence and normal viewing.

†Thickness measurements at 5 equally spaced points near backbone line, starting about 8 inches from tail and ending at shoulder.

‡See text for method of measurement.

§Standard error.

TABLE X  
ANALYSIS OF VARIANCE OF PHYSICAL MEASUREMENTS GIVEN IN TABLE IX

Determination	Source	Degrees of Freedom	Mean Square
Color.....	Lot.....	10	288.38*
	Error.....	722	3.40
Weight.....	Lot.....	10	4770.43*
	Error.....	722	876.04
Area.....	Lot.....	10	0.89*
	Error.....	722	0.32
Stiffness.....	Lot.....	10	801.27*
	Error.....	722	29.78
Thickness.....	Lot.....	10	0.2446*
	Position.....	4	1.0945*
	Lot x Position.....	40	0.0053
	Error.....	3610	0.0074

\*Significant at 1 per cent point.

lightness (disregarding Lot D) was as follows: *R. coriaria*, *R. copallina*, *R. glabra* and *R. typhina*.

In general appearance the Sicilian sumac tanned skivers were enough lighter to be distinguishable from the other lots, although there was, of course, considerable variation in individual skivers. Lot D, which was tanned with red leaves, was darkest or reddest, but the difference between it and the other lots was much less than at the crust stage. The red dye or coloring matter is water soluble, is only loosely fixed by hide and is largely removed during fatliquoring and finishing operations. In the finished, lacquered leather the fact that it had been tanned with red leaves was not noticeable on either the grain or flesh sides of Lot D. There were highly significant differences between the average weights of the skivers in the different lots. *R. copallina* and *R. typhina* leaves produced the heaviest skivers; *R. glabra* and *R. coriaria*, skivers of intermediate weight; and *R. typhina* leaflets, the lightest skivers. Both lots of *R. typhina* leaves produced appreciably heavier leather than the corresponding leaflets, but there was no difference in weight-giving properties between leaves and leaflets in the one comparison with *R. glabra*.

Area variations, although statistically significant, were much less pronounced than the weight variations and were not related to species of sumac, as the differences between species were not significant. In fact, the greatest differences were between the three lots of *R. copallina*.

Thickness was measured in five places on each skiver near but not on the backbone line, starting 8 or 10 inches from the tail and ending at the shoulder. The gauge foot was moved about at each location to obtain an

estimated average value. The skins were irregular, but it was not considered worth while to make the large number of readings that would have been necessary to obtain an accurate average thickness value for each skiver. An attempt was made to be consistent throughout the series; all measurements were made by the same operator. As can readily be seen from the data, there was a large variation due to location. The first reading near the tail is highest, the third at the center of the skiver is lowest, and the fifth value at the shoulder is intermediate. The thickest part of the skiver may have been in the neck or head, but no measurements were taken there. The differences in thickness in the skivers are the same as those in the original skin, because the flesh split was of uniform thickness. Although the greatest variation was due to position, the analysis of variance in Table X shows that there were highly significant differences between the lots. *R. copallina* produced the heaviest as well as the thickest leather, and *R. typhina* produced the lightest in weight and thinnest of any of the lots; that is, an increase in weight was accompanied by an increase in thickness. Weight is a function of area, thickness and density, and as area was approximately constant there probably were only minor differences in density between the various lots.

Stiffness was measured by laying a skiver on a level table top, placing the head gently on the tail, adjusting the skiver so that it formed a smooth, loose fold perpendicular to the backbone and then measuring the height of this fold with a cathetometer. Two measurements were taken, one with the grain out and the other with the flesh out. Since no consistent differences due to direction of fold were found, the two values were averaged.

A striking difference is at once evident on examining the data. All the leathers had approximately the same stiffness except those tanned with *R. copallina*. The latter were appreciably more flexible, or less stiff, than the others. The method of measuring stiffness used here may be considered a crude form of the "angle of droop" method in which density and thickness are factors. A thick leather would be expected to give a higher reading than a thin leather if they were otherwise comparable, and a leather with a greater weight per square foot should give a low reading. Leathers of equal apparent density, however, should give readings proportional to their stiffness. The stiffness values obtained here do not appear to be affected greatly by weight or thickness; at least lots G and K, although heavier than lots H and L, do not differ from them in stiffness readings. On the other hand, lots A and K, and also B and G, do differ in stiffness values but not in weight. No explanation for the difference in behavior of *R. copallina* and the other species is evident.

No other measurements were made on the 733 marked skivers as a whole, but 15 skivers from each lot, or a total of 165 skivers, were retained for addi-

tional physical measurements and for chemical analysis. A future report on this work is planned.

### Conclusions

From his observations of the skivers throughout the tanning and finishing processes, the tanner arrived at the following conclusions:

"There are varieties of native American sumac which, if properly collected and prepared, can be used for tanning skivers which compare favorably with those tanned with Sicilian sumac.

"The tanned skivers are not quite equal in shade, weight and feel but can be used to replace those tanned with Sicilian sumac for most purposes.

"*R. copallina* gives the best results, *R. typhina* is second best and *R. glabra* is poorest. The last tans slowly and apparently the tannin washes out of the leather when it is colored, which makes a tinny, harsh leather.

"On an equal price basis, Sicilian sumac will be preferred to American. If the quality of cultivated American sumac can be brought up to that of Sicilian, there should be no difference in price.

"Shade is not so important to the tanner as it is to the extract manufacturer. The tanner is more interested in weight and feel and requires a minimum of 26 per cent tannin in ground sumac but prefers 28 to 30 per cent."

The domestic sumacs compared favorably with Sicilian sumac in ability to impart weight, area, thickness, and stiffness to leather. Although Sicilian sumac was better in both color and feel than domestic sumac, the differences were not great and could be detected only by careful observation. The leathers tanned with domestic sumac were as satisfactory for the purpose for which they were used as the leather tanned with Sicilian sumac, demonstrating that it is possible to produce a domestic sumac that is entirely satisfactory for certain tannages.

The domestic sumac was handled as well as commercially collected sumac under the most favorable circumstances, but even after purification by elutriation, it did not yield a product fully equal to Sicilian sumac. Apparently the best prospect for obtaining a domestic product equal or superior to Sicilian sumac is in breeding and propagating a variety that is better than the ordinary wild species.

The relative value of the three domestic species, in order of their preference by the tanner, was *R. copallina*, *R. typhina* and *R. glabra*. The physical tests give the order as *R. copallina*, *R. glabra* and *R. typhina*, but this evaluation includes color, in which the tanner was not interested. If color is omitted from consideration there is little choice between *R. glabra* and *R. typhina* or between these and Sicilian sumac in weight, area, thickness, and stiffness. *R. glabra* may be considered preferable to *R. typhina* because of its slightly higher tannin content and the fact that elutriation of the latter

to increase its tannin content and improve the color of leather tanned with it, resulted in leather that was a little thinner and lighter in weight than that obtained with whole leaves. Differences between the three domestic species are not great, and future work may make necessary some modification or amplification of these conclusions regarding their relative value.

It probably should be pointed out here that, although satisfactory leather was produced with every lot of sumac in these tests, including the one containing only 19 per cent of tannin; a full pack of 30 dozen skivers was not tanned with lots that were low in tannin. In order to use domestic sumac of poor quality the tanner would find it necessary to decrease the number of skivers per vat. This would increase costs and might lead to irregular or unsatisfactory results.

### *Summary*

Fifteen packs of sheepskin skivers, each consisting of from 21 to 33.5 dozen skivers, were tanned with 4 lots of *Rhus copallina* leaves, 2 lots of *R. glabra* leaves, 3 lots of *R. glabra* leaflets, 2 lots of *R. typhina* leaves, 2 lots of *R. typhina* leaflets, and 2 lots of ground Sicilian sumac. Satisfactory commercial leather was produced by all lots, although some were so low in tannin that it was necessary to reduce the number of skivers in the pack below the normal 30 dozen. None of the lots of domestic sumac produced leather quite equal to that produced by Sicilian sumac. The order of preference, as expressed by the tanner, was *R. coriaria* (Sicilian), *R. copallina*, *R. typhina*, and *R. glabra*.

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